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ON THE INDUCTIVE CAPACITY OF A SPHERE WITHIN A SPHERICAL SHELL.

By H. R. KEMPE.

In order to calculate the inductive capacity of a sphere placed concentrically within a spherical shell, we must suppose the propagation of the inductive action from the sphere to the shell to take place in concentric spherical shells.

Now the resistance ρ to the inductive action through such a shell will be directly proportional to its thickness, and inversely proportional to its surface and also to the specific inductive conductivity of the dielectric separating the sphere from the shell.

Calling then the radius of the sphere r, the radius of the shell R, the specific inductive conductivity of the dielectric s, and the total inductive resistance ρ, the inductive resistance of a differential shell of radius x and of a thickness dx will be—

$$d\rho = \frac{dx}{4\pi x^2 s}.$$

Integrating between the limits, $x=r$ and $x=R$—

$$\rho = \int_r^R \frac{dx}{4\pi x^2 s} = \frac{1}{4\pi s}\int_r^R \frac{dx}{x^2} =$$

$$= K\left(\frac{1}{-R} - \frac{1}{r}\right) = K\frac{R-r}{Rr}$$

where $K = \frac{1}{4\pi s}$, a constant.

If, now, we have a second shell whose radius is R_1, the inductive resistance ρ_1 between this shell and the sphere whose radius r will be—

$$\rho_1 = K\frac{R_1 - r}{R_1 r}$$

and—

$$\rho : \rho_1 :: K\frac{R-r}{Rr} : K\frac{R_1 - r}{R_1 r}$$

that is—

$$\rho : \rho_1 :: \frac{R-r}{R} : \frac{R_1 - r}{R_1}.$$

Now, the inductive capacity varies inversely as inductive resistance. Calling, then, C the inductive capacity of the element whose inductive resistance is ρ, and C_1 the inductive capacity of the element whose inductive resistance is ρ_1, we shall have—

$$C : C_1 :: \frac{R}{R-r} : \frac{R_1}{R_1 - r},$$

that is to say, the inductive capacity of a sphere placed concentrically within a shell varies directly as the radius of the shell and inversely as the thickness of the dielectric.

Now, if r, the radius of the sphere, be very small compared with the radius of the shell, that is, if r may be made equal to 0, then we get—

$$C = C_1,$$

that is to say, the inductive capacity will remain the same no matter what size the shell be.

ELECTRO-DEPOSITION OF METALS.

By J. T. SPRAGUE.

In the working out of the various arts which are the basis of our modern civilisation there are two classes of operators, two lines of operation, as to the relative value of which there are frequent discussions—these are the practical and the theoretical. Those who devote themselves exclusively to one of those branches are very apt to look with some contempt upon the other. It only needs a clear understanding of what these two things—practice and theory—really mean, to understand that they are indispensable to each other: practice means the knowledge *how* to do a thing, and theory means the knowledge *why* it should be done. It follows, therefore, that theory is the wise examination of the results of good and wide practice, and that practice alone is mere rule-of-thumb working, and can scarcely ever lead to any improvement.

The object of these papers will be to combine these two principles; not merely to give crude formulæ, or processes to be followed unintelligently, but to combine with these such an outline of the principles involved as will enable the reader to apply them in the many varying conditions likely to arise.

Electrical operations, like mechanical ones, consist of two distinct parts. (1.) The generation or collection of energy from some source. (2.) The application of that energy to effect the desired purpose, and this latter is divisible into two parts, that is to say, the conveying the energy to its work, in which process it is partially expended, and doing the actual work. Be the work we have to do what it may, one universal law governs all; we must expend in doing it energy equivalent to the work and all the operations incidental to it; under no circumstances will the work do, or help to do, itself; this may seem a mere truism, yet the want of understanding it costs this country many thousands every year. Economy, that is true practical working, consists in obtaining the necessary energy at the lowest cost, and in avoiding all loss in applying it when obtained.

Thus, in ordinary mechanics, it is necessary to select the cheapest fuel, the best furnaces and boilers, then to avoid loss of heat in the steam pipes, or undue friction in the engine and connected machinery: at every stage there is room for a wise understanding of principles, and a due application of them. Electrical operations are perfectly analogous and require similar attention. Thus the battery or other motor represents the boiler with its fuel, the conducting wires replace the steam pipes, and the work to be done and apparatus for doing it are the analogue of the engine and the machinery it may drive; while the steam itself, with its capacity for bearing pressure, and thus conveying the energy derived from the combustion of the fuel, strongly resembles the electric "current," with the various tensions which set it up and give it power.

We are thus led to the three fundamental expressions employed in the laws of electricity known as Ohm's formulæ, viz., electro-motive force, resistance, and current. It is upon a clear understanding of these, in a perfectly definite form in place of the confusion of the old vague terms "quantity and intensity," that sound and economical working must be based.

Electromotive Force is a general term for any cause whatever which sets up electric tension, or a tendency to electric current. In the British Association system of measurement, its unit is the volt which is a little under the force of a Daniell's cell.

Resistance is that property of matter which tends to prevent current passing, and every separate substance has this in its own degree, or what is called its specific resistance, absolute for any given circumstances, but varying with varying heat and other causes. Bodies having small resistance are called conductors, those having large resistance insulators; but all conductors offer some resistance; all insulators conduct in some degree. The unit of resistance is the Ohm.

Current (or what used to be called quantity) is the rate of electric action generated under any given conditions of electromotive force and resistance, and its unit is called the veber. There is for practical purposes a very much superior unit of measurement which will be explained hereafter.

Ohm's Formula, $C = \frac{E}{R}$, shows the interdependence of these several elementary terms. It teaches that, measured in systematic units, electromotive force divided by resistance gives the current which can pass, that is to say—

$$\frac{\text{Electromotive Force}}{\text{Resistance}} = \text{Current.} \quad \frac{\text{Volt}}{\text{Ohm}} = \text{Veber.}$$

$$\frac{1}{1} = 1; \quad \frac{2}{1} = 2; \quad \frac{1}{2} = 0{\cdot}5, \text{ or half,}$$

so that when we require a current of any particular strength, all we have to do is to ascertain the resistance we have to overcome and apply to it the proper electromotive force. Understanding this, we can balance our means to the end desired, and that is economy, or avoidance of waste.

So it follows that $C \times R = E$, or the current and resistance being known, they give, when multiplied together, the electromotive force of the circuit.

Also $\frac{E}{C} = R$, or knowing the force of battery used, and measuring the current, we ascertain at once the resistance of the circuit.

The first subject to be considered, then, is the generation of the energy, the best source, that is, of the required electromotive force. In any case this must be derived from the destruction of some substance which will furnish it. This may be coal or any other combustible, which, by means of an engine, will drive a magneto-electric machine, and so furnish a current. This process is destined probably to be our chief source of electricity; it is already used in some cases, but it is a subject by itself, and all I propose to say about it here is that it is subject to exactly the same laws as any other source of "current;" it must be arranged to give the force adapted to the particular work, and be duly applied. For all ordinary purposes, some of the forms of galvanic cell (usually but wrongly called battery) is employed, and a clear understanding of the principles involved in these will not only facilitate the choice of that best adapted to any purpose, but will also furnish the knowledge of the principles involved in applying them to their work.

The usual unit of measurement for mechanical energy in this country is the foot-pound, that is to say, the work expended in lifting a pound weight one foot against the force of gravity; and as all the different forms of work or energy are interchangeable in definite or equivalent values, from this unit we can ascertain the corresponding value as heat or as electrical action, while this unit conveys a more definite idea to most minds than the special units do. Every conceivable action, therefore, may be expressed in foot-pounds; every effort made, every action performed against any resistance, therefore, requires a definite expenditure of so many foot-pounds of energy; every chemical action either produces or absorbs its own definite value; and it may be stated in broad terms that every act of chemical combination gives out energy, and every act of chemical decomposition absorbs, or requires energy to be put into it. Thus, when we burn any substance, we get energy given out as heat; when we want to reduce or unburn a substance, as in obtaining a metal from its ore, we must put back that heat into it, and we must put back exactly the same heat as it would give up in burning. This is the one universal law the want of understanding which produces believers in perpetual motion; it is the law of equivalent expenditure of energy for all work done.

Combustion is the union with oxygen at a rapid rate, but in principle it is simply a chemical combination, and all combinations obey the same laws; each individual combination gives out a definite or specific amount of energy, and to decompose that combination, *exactly that same energy* must be put back into the elements of the substance. This is what is effected by the chemical actions of the galvanic current.

Carbon, when burnt in oxygen, gives per pound 11,228,000 foot-lbs.; hydrogen, 47,887,000; and coal, which is a compound of these, has a similar theoretical value, of which, from the various sources of waste, only about one-tenth appears available in the steam-engine, and much less, again, in actual work done. Zinc burnt in oxygen gives per lb. about 1,845,000 foot-lbs.

But it is only that class of "practical" people who profess contempt for theory who should confine their attention to pound weights; these give no real knowledge. Just as each chemical action involves a definite amount of energy, so it involves a definite amount of each kind of matter which enters into the reaction. These definite amounts are expressed in chemistry as atoms and equivalents, and it is useless to expect to get any understanding of electrical processes without first clearly comprehending these terms.

Matter exists, as far as we can ascertain, in about 64 different forms, of which all substances are composed. These distinct forms of matter are called *elements.*

Each and all the elements are believed to exist in the condition of minute particles, all distinct, and having an exact relative weight for each element. These particles are called *atoms*, and their relative weight, as compared with the lightest known form of matter (hydrogen), is called the *atomic weight.*

Actual substances are composed of minute distinct particles, which, in elementary substances, are composed of two (sometimes more) atoms of the same element. Compound substances are composed of two or many atoms of different substances associated together in a definite manner. These particles are called *molecules*.

The atoms of the elements possess different powers of combining with other atoms, and are thus capable of arrangement in classes; but some elements vary in their combining capacity, and belong to two or more classes. The salts of these elements are distinguished in different classes by the terminations *ous* and *ic*, as in the case of iron, which has ferrous oxide, FeO, and its corresponding series of salts, and ferric oxide, Fe_2O_3, and its series. In these cases, it is considered that two of the ordinary atoms unite together, and act as a single atom with its own combining capacity. These capacities of atoms are called their *valency*, and they are classed as monads, dyads, &c,, according to the number of atoms of hydrogen (or other singly valent element), which they are capable of uniting with directly, or of replacing in a combination.

The atomic weight, divided by the valency of an atom, usually gives a weight which agrees with what used to be called the *equivalent*, but this is not always the case, and it is essential to maintain a clear conception of the several meanings of eqnivalents, atoms, and molecules; for the relation of electricity to matter, its passage through, and its effects upon, various substances, are absolutely linked to, and wholly dependent upon, the atomic weights of the various substances, upon the valency of the atoms, and upon the consequent construction of the molecules of each distinct substance.

MATHEMATICS
FOR
NATURAL SCIENCE STUDENTS.

By T. C. SIMMONS, B.A. Magdalene College, Cambridge.

(Continued from page 83.)

SIMPLE EQUATIONS (*Continued*).

BEFORE proceeding to the study of quadratic equations, I shall make a few more remarks on simple equations, as the subject is so important that it is necessary for the student to have a clear and thorough comprehension of it.

In my last paper, I showed how to solve simple equations, and gave a few examples for the student to work out by himself. I may remark that he may make for himself equations to any extent he pleases, and can test the accuracy of his solution by substituting the value he finds for x in the original equation, and seeing if it is satisfied. Thus, suppose he forms for himself the equation—

$$\frac{x}{2}+\frac{x}{3}-\frac{x}{4}=\frac{1}{2}$$

and finds the solution $x=\frac{6}{7}$, and is doubtful whether this is correct, he may test it as follows:—

In the equation, put $\frac{6}{7}$ for x, and we get—

$$\frac{\frac{6}{7}}{2}+\frac{\frac{6}{7}}{3}-\frac{\frac{6}{7}}{4}=\frac{1}{2}.$$

or

$$\tfrac{3}{7}+\tfrac{2}{7}-\tfrac{3}{14}=\tfrac{1}{2}$$

or

$$\tfrac{6}{14}+\tfrac{4}{14}-\tfrac{3}{14}=\tfrac{1}{2}$$

or

$$\tfrac{7}{14}=\tfrac{1}{2},$$

which is obviously true. But if he had found, say, $x=6$, he would get, by substitution—

$$\tfrac{6}{2}+\tfrac{6}{3}-\tfrac{6}{4}=\tfrac{1}{2}$$

or

$$3+2-1\tfrac{1}{2}=\tfrac{1}{2}$$

or

$$3\tfrac{1}{2}=\tfrac{1}{2},$$

which is an absurdity. Thus he knows that the solution $x=6$ is wrong.

I may perhaps remark that the above equation is the same as—

$$\tfrac{1}{2}x+\tfrac{1}{3}x-\tfrac{1}{4}x=\tfrac{1}{2}.$$

It is usual, however, not to use fractional coefficients with x, but to make the whole term, including x, a fraction. Thus, instead of expressing the fact that $\frac{4}{5}$ of x added to $\frac{1}{5}$ is equal to $\frac{3}{7}$ of x added to 2 in the form—

$$\tfrac{4}{5}x+\tfrac{1}{5}=\tfrac{3}{7}x+2,$$

it is more usual to put it thus—

$$\frac{4x}{5}+\frac{1}{5}=\frac{3x}{7}+2,$$

or

$$\frac{4x+1}{5}=\frac{3x}{7}+2.$$

If the student solves this in the usual way, he will find, on multiplying by 35—

$$28x+7=15x+70$$
$$13x=63$$
$$x=\tfrac{63}{13}$$

and he can test it thus—

$$\frac{\frac{252}{13}+1}{5}=\frac{3\times 63}{7\times 13}+2$$

or

$$\frac{265}{13\times 5}=\frac{3\times 9}{13}+2$$

or

$$\tfrac{53}{13}=\tfrac{27}{13}+\tfrac{26}{13},$$

which is obviously correct. Thus he knows that $\frac{63}{13}$ is the accurate solution. I would recommend him to form for himself equations, and solve them, and substitute the value he finds for x in the equation, and so find, by himself, whether he is right or wrong. When he has done this in a great many instances, and finds that he readily and correctly solves the equations he forms, he may be sure that he understands the subject. He must always bear in mind that he will never make much progress in mathematics unless he works out a great number of examples. The old maxim that practice makes perfect holds true perhaps in nothing so much as it does here.

It may be as well if I suggest a number of equations. I need not give the solutions:—

(1). $\dfrac{x+3}{2}-\dfrac{x-2}{3}=\dfrac{3x-5}{12}+\tfrac{1}{4}$

(2). $\dfrac{2x-6}{5}-\dfrac{x-4}{9}-\dfrac{3x}{13}=0$

(3). $\dfrac{5x-3}{7}-\dfrac{9-x}{3}=\dfrac{5x}{2}+\dfrac{19}{6}(x-4)$

(4). $\dfrac{x}{2}+\dfrac{x}{3}+\dfrac{x}{4}=13$

(5). $3x-4=24-x$

(6). $\dfrac{x}{4}-4=\dfrac{5x}{3}-\tfrac{7}{6}$

The student must be careful to deal properly with the sign $-$. Thus in (1), for instance, he will proceed thus:—

Multiply by 12. Then—

$$6x+18-4(x-2)=3x-5+3$$

or

$$6x+18-4x+8=3x-5+3$$

or

$$-x=-28$$

or

$$x=28.$$

He will remember that when the sign $-$ occurs before a fraction, as $-\frac{x-2}{3}$, he must treat it as he would treat a bracket, for $\frac{x-2}{3}$ is merely another way of expressing $\frac{1}{3}(x-2)$. He will always bear in mind that when he removes the bracket from any expression, and the $+$ sign occurs before the bracket, the signs of all the terms within the bracket will be unaltered; but if the $-$ sign occur, they will all be altered. Thus—

$$3+4(2-3) \text{ stands for}$$
$$3+4\cdot 2-4\cdot 3$$

or

$$3+8-12.$$

while

$$3-4(2-3) \text{ stands for}$$
$$3-8+12.$$

In solving (6), too, he will find $x=-2$ and in testing the solution, he will put—

$$-\tfrac{2}{4}-4=-\tfrac{10}{3}-\tfrac{7}{6},$$

or, changing all the signs, for convenience—

$$\tfrac{1}{2}+4=\tfrac{20}{6}+\tfrac{7}{6}$$
$$\tfrac{9}{2}=\tfrac{27}{6}.$$

The same equation might, however, have been written—

$$4-\frac{x}{4}=\tfrac{7}{6}-\frac{5x}{3}$$

and then we should have tested it thus—

Multiply by 12; this will simplify it (we might have done the same thing in the method of testing given above), and we get—

$$48-3x=14-20x$$

and on substitution—

$$48-3(-2)=14-20(-2)$$

or

$$48+6=14+40$$

or

$$54=54.$$

I would recommend him, though, to substitute before he multiplies, as possibly he may make a mistake in multiplying the equation when he solves it, and repeat the same mistake when he multiplies for testing it, and so will not discover his error.

It is always advisable, if we have solved any problem or example, and are not certain as to the correctness of our result, to solve it again, if possible, by a totally different method. If we arrive at the same result again, we may feel tolerably sure that it is correct.

How to Apply Simple Equations to the Solution of Certain Problems.

The student has not yet seen the use of equations. I will give some questions which it would be difficult, and perhaps impossible, to answer by mere arithmetic, but which can be easily and readily answered by means of simple equations. They are not, perhaps, of much practical value, and it is not likely that they will ever occur in real life, but still they are useful as giving the student an interest in what he is doing. No one will ever be able to apply his mathematics to questions which may occur, say, in electricity, unless he has become familiar with the methods of applying them to questions which he will never be called upon to solve in his practical career, and which perhaps may look more like puzzles, or exercises of ingenuity, than anything else.

Suppose, for instance, he is called upon to give an answer to the following question:—

> A person spends one-third of his income in board and lodging, one-sixth in clothing, and one-tenth in charity, and saves £48. What is his income?

The income being the thing we wish to find, let us denote it by x pounds. Then $\frac{1}{3}.£x$, added to $\frac{1}{6}£x$, added to $\frac{1}{10}£x$, added to £48, is equal to the whole income, or to $£x$: We have, therefore, for finding x, the equation—

$$\frac{x}{3}+\frac{x}{6}+\frac{x}{10}+48=x,$$

or, since $\frac{x}{3}+\frac{x}{6}$ is the same as $\frac{3x}{6}$, or $\frac{x}{2}$,—

$$\frac{x}{2}+\frac{x}{10}+48=x.$$

Multiply by 10, then—

$$5x+x+480=10x$$
$$-4x=-480$$
$$x=120$$

Thus, his income is £120. We can easily test the answer in this way. If his income is £120, one-third of it is £40, one-sixth £20, and one-tenth £12; and—

$$£40+£20+£12+£48=£120.$$

The student may solve the following by himself, and should test his answer to see if it is correct:—

> The property of two persons amounts to £1200, and one is twice as rich as the other; what is the property of each?

The following is a question more of a practical nature:—

> Divide a line 21 inches long into two parts, such that one may be three-fourths of the other.

Let x inches be the length of one portion. Then—

$$x+\tfrac{3}{4}x=21$$
$$4x+3x=84$$
$$7x=84$$
$$x=12$$

Thus, one part is 12 inches long, the other 9 inches.

Again—

> Divide £210 among two persons, so that for every shilling one receives, the other may receive half-a-crown.

Here, if the first receives x shillings, the other will receive $2\frac{1}{2}x$ shillings, and we know that the whole number of shillings is 210×20 or 4200.

Thus—

$$x+2\tfrac{1}{2}x=4200$$
$$2x+5x=8400$$
$$7x=8400$$
$$x=1200$$

Thus, one receives 1200 shillings, or £60, and the other, of course, £150. We can easily test it thus:—

£150 contains 150×8 half-crowns, or 1200 half-crowns, and we know that the first one receives 1200 shillings. Thus our solution is correct.

Again—

Two stations are a certain distance apart. Two trains travel between them, one at the rate of 20 miles an hour, and the other at the rate of 30 miles an hour; the first takes an hour longer to perform the journey than the other. Find the distance.

Let x be the distance in miles. Then $\frac{x}{20}$ will be the number of hours occupied in travelling by the first train, and $\frac{x}{30}$ the number occupied by the second—

$$\therefore \frac{x}{20} - \frac{x}{30} = 1$$

Multiply by 60. Thus—

$$3x - 2x = 60$$
$$x = 60.$$

Thus 60 miles is the distance, as is easily seen by testing it.

There will, I think, be no difficulty in solving and testing the following:—

(1). A person saves half as much money as he spends, and his whole income is £300. Find his expenditure.

(2). Two persons, A and B, have equal quantities of money. A gives B £30, and then B is twice as rich as A. Find how much each had at first.

(3). Two places are a certain distance apart. A person walking at the rate of 5 miles an hour travels from one to the other, and takes an hour less to perform his journey than another person walking at the rate of 4 miles an hour. Find the distance.

The student has now become sufficiently acquainted with simple equations for all practical purposes. He cannot, however, be too strongly recommended to make up a great number of them for himself, and test his solutions. He will by that means not only gain facility in working out equations, but will gradually become familiar with algebraical processes generally.

THE PRINCIPLES AND PRACTICE OF ELECTRICAL TESTING.

By SAMUEL E. PHILLIPS.

I.

THERE appears to be a want of a more simple introduction to the principle and practice of electrical testing, many junior students being often unable to follow the abstract methods and formulæ employed by our leading writers.

The structure of any galvanometer, the working out of any process, all is based on the fundamental principles of electricity and magnetism; and as much of hypothetic refinement has been associated with them, we advise that the student should carry about with him a clear and firm grasp of the simplest and truest aspects of the case; for that student who builds on the secure basis of real knowledge is far more likely to succeed than one who, without being duly warned, has incorporated much of hypothesis in the substratum of his acquirements.

We will therefore commence this series of articles with a few remarks on the essentials of what is really known in regard to electricity and magnetism. It is important for the student to understand that electricity is dynamic, while magnetism is static; there is no such thing as a magnetic current. The setting up of magnetism is a dynamic effect, and is essentially voltaism; and, however understood or designated, it has all the properties of a voltaic current, during the time of its continuance: but first of all we are concerned with electricity, and here the word dynamic requires qualification.

Light, heat, and sound are dynamic; at any rate, in the propagation of sound, we know that force only is transmitted; it is motion *per se*, whereas electricity is an absolute atomic interchange or transfer. The attempts to view it under the former category are many, and a fashionable leaning in that direction is evident; but that it is otherwise is matter of absolute knowledge.

We are taught in the manuals that static or tension electricity is produced by friction; and that voltaic electricity is the result of chemical action. Some time ago, however, there was a long dispute as to whether it owed its origin to the mere contact of different metals, or to chemical action; and now, after a wide settlement in favour of the latter, the question again turns up, owing to the new experiments of Sir W. Thomson in favour of the former. We may therefore look for some eminent re-statement of the case, and in some faint anticipation of that, I would, eschewing the former distinctions, say that in every case electricity is produced by a two-fold process. (1.) There must be a contact or juxtaposition of two electro differing substances; and (2.) The polarities thus disturbed, condensed, or intensified, can only be accumulated by motion, friction, or chemical action.

In the old frictional machines, in the varied forms of the Holtz machine, or in Thomson's replenisher, these polarities are accumulated by rapid motions of either friction or juxtaposition. We shall have to consider them further in future details, but all we here require of the student is a clear comprehension of the general principle.

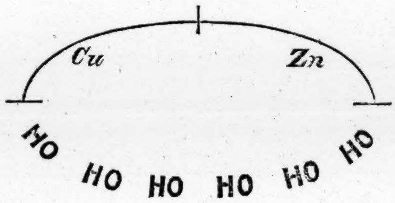
Let us imagine two insulated Leyden jars, A quite neutral, and B somewhat positive on the outside. Now on bringing A very near to B, its neutrality is inductively disturbed; and by a dexterous manipulation of contact it may be robbed of this polarity; and any ingenious repetition of these movements will exalt this difference, which may be diverted, first of all, to increase the original charge at B, and, secondly, to any desired external work. How this is done practically in the instruments of Thomson, Holtz, or Gramme, will also be matter of future detail, but our concern here is to show that the same principle is evinced in the battery production of a voltaic current.

Zinc and platinum, carbon or copper, are the two differing electromotors, and what we otherwise do by mechanical ingenuity, is automatically done by chemical action. How this is effected, and the economy of varied forms of battery construction will come on in future papers; but the general principles alike in all should be clearly understood at the onset.

The electro-difference of, say zinc and platinum, is the stock-in-trade or the electromotive force, which is unaffected by the size of plates, or the quantity of action involved. Oxygen is attracted to, and combines with, the zinc on one side; and hydrogen tends to, or is liberated from, the other; and as these atoms cannot go through each other, they must interchange spirally or in some other way; and in doing so, they act inductively all round the circuit, or at right angles to their course. The oxygen may be replaced by chlorine or any negative constituent, the fact being that electrolysis consists in a certain form of transfer of the negative element to one side and a corresponding transfer of the positive element to the other side or pole. It is no less indisputable that in every case static polarity or magnetism is evinced all round any such circuit of action. Were I to describe what takes place in the copper or other leading wires, in completion of the circuit, it might be somewhat hypothetical, and this I am anxious to minimise or defer; but it must be insisted on that this completion of the circuit is a necessary element, so it is matter of plain inference that the character of action on both sides of the circuit is identical.

The very simplest diagram of battery action

FIG. 1.



would represent two equal and opposite halves, one metallic, the other liquid. This simplicity is modified in practice by diminishing the area of the relatively bad conducting fluid, by adding acid to remove the insoluble oxide of zinc, and by extending for use and convenience the good conducting copper; but the essential facts remain intact, that for every O lost on one side by the liquid half, a corresponding Zn is given up on the other, or metal half. One is the necessary complement of the other, and they are both the product of one circuit of atomic interchange or transfer.

The sum of all this is that electricity is a circuit of atomic interchange, and the static forms are merely exceptional cases where undue resistances are brought into play. In principle, it is immaterial whether these polarities are accumulated by friction, and insulated for a time by the resisting glass of a Leyden jar, or, being accumulated by chemical actions, they are insulated for a time by the resisting dielectric of an ordinary condenser. In both cases, the principle is one.

Magnetism is a universal affection. It is the directivity of atoms, and necessarily inherent in their diversity. It is the origin of all electrical action, and may be seen in a thousand forms of crystallisation, but recognised in the books only in some metals which evince for its exhibition a peculiar susceptibility; and of these iron is especially the most prominent. A current of electricity passed several times round a bar of iron induces therein a powerful directivity, a polarity or magnetism, and in proportion as the iron is hardened, as in the case of steel, will that polarity be more or less permanent.

It is from this extreme case that all our ideas of polarity are derived, and hence the definition "opposite properties on opposite sides."

Such, then, is the simplest estimate of the two constituent bases of all electrical science. We cannot profess to bring to bear, if the space here permitted, either the talent or the time for a systematic development of the great subject as a whole, but having craved a special attention thus far, we may incidentally illustrate the leading principles of applied electrical science in a popular glance at some of the practical details.

ON THE CONDUCTIBILITY OF MAGNETIC TENSIONS.*

By M. JAMIN.

THE expression, *coercitive force*, has been used to express the difference between iron and steel. The force is defined as the difficulty experienced in magnetising the metal, and the resistance it opposes to causes of demagnetisation. This is vague, and not based on any definite experiment.

I take a horizontal bobbin 15 centimetres in length, and pass through it a current of 20 Bunsen elements. I place within it a prismatic soft iron core of the same length, which is magnetised, and takes (say) austral magnetism at its anterior end. I bring gradually near to this the end of a horizontal iron bar; it undergoes magnetic induction, taking a contrary or boreal tension at the nearer end, and austral at the further. On contact occurring, the boreal tension is wholly concentrated at the surface of contact, concealed by an equal magnetism accumulated in the core. There only remains austral tension, prolonged from this core to all points of the bar.

Note two things—1. The tension, measured by the force of detachment of a proof-contact, is always the same on the two sides of the surface of contact (the core on one hand, the bar on the other). There is magnetic equilibrium, without difference or fall, between the two metals. 2. The austral tension continues along the bar to its free end, almost without diminution of intensity, if the bar do not exceed 85 centimetres.

We thus see that soft iron has the double property of becoming in equilibrium of tension with a magnet it may touch, and of propagating this tension through its substance to considerable distances. This is its essential character, which might be expressed in a word, by saying that it is a *conductor of magnetic tensions*.

The distribution of these tensions varies with the form and extent of the bars. It follows a very simple law where the bars are of infinite length, and inserted at one end within the bobbin. It is natural to suppose that, in this case, the tension of each infinitely thin section is a constant fraction of the preceding section, which at once leads to the formula—

$$I = \frac{M}{a^x}.$$

Experiments towards verifying this formula were made with three soft iron bars, 2 metres in length, and of square section, with sides of 20, 15, and 10 millimetres. I measured the tensions from decimetre to decimetre, starting from the internal surface of the bobbin. [The numbers are given in a table]. The relation a is constant, and equal to 1·312 for the three bars studied. That is to say, the same metal transmits from one section to that which follows a fraction of its magnetism which depends on its nature but not on its section. But if a is independent of the section, it is otherwise with M, which is proportional to the side (width), b, of the bar. It is equal to 7, if this side = 1 millimetre. We have in general—

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* Abstract of note to the Paris Academy.

$$I = 7 \frac{b}{(1\cdot312)^x}.$$

Next, consider steel. I examined three specimens. . . . . When one of the bars is neared to the electro-magnet, it is influenced like iron, but with this difference, that the action is less marked, and that, at contact, the bar has always a weaker tension than that of the core. There is a difference,—a fall, which is greater the richer and harder the steel. As to the curves of tensions at different points of such bars, they satisfy the same formula; but (1) M is less, (2) a is greater the richer and better hardened the steel. Thus the curves sink more and more, and are less and less prolonged. [This, also, is shown by tabulated numbers]. It is these properties that the expression *coercitive force* has been supposed to explain. It seems to me they might be expressed in a more clear and simple way by saying that soft iron is a good conductor of magnetic tensions, and that steel is the less so the harder it is.

We may complete our ideas by studying what occurs when the bars are withdrawn from the electro-magnet. Before separation, they have at the surface of contact a boreal polarity concealed by an equal quantity of the contrary magnetism in the core; they have, moreover, the long curve of austral tensions (as above pointed out). Immediately the separative action of the magnet ceases, these magnetisms re-unite, so far as the conductivity of the metal allows, entirely, if it is iron, partly, if steel; and in this case there remains—1. At the end, a very strong boreal pole; 2. A neighbouring region, where the tensions most nearly related are recombined, and a middle line, which is nearer as the conductibility is less; 3. Extending to the limits of the curve of the first tensions, an austral polarity, very prolonged and diffuse, and so, scarcely appreciable at each point; 4. The opposite end is absolutely in the natural state. [A specimen of this singular magnetisation was exhibited].

It is because iron is a conductor (of magnetic tensions) that it takes and loses magnetism immediately an exterior cause intervenes or disappears; it is for the same reason that it transmits, through a contact, the opposite tensions of the two poles, and that it brings the magnet to neutrality. It is thus, still further, that, by means of armatures carefully applied, it serves to unite and to transport to neighbouring polar masses the magnetism scattered on the surfaces of natural magnets. On the other hand, it is by reason of its little conductibility that steel keeps separated the contrary tensions at the ends of a bar, and the more powerfully the longer it is. We may, similarly, explain the necessity of friction in magnetisation to act on each point and supply the conductibility which is lacking; the impossibility of making contacts with steel; and lastly, the difference of tension maintained between this metal and a magnet touched by it.

THE HISTORICAL DEPARTMENT OF THE GERMAN TELEGRAPH EXHIBITION AT VIENNA IN 1873.

THE Annexé of the Gallery of the German Empire (viii.*a*) contains a treasure which must have a peculiar charm for any one who has marked the significance of telegraphy for the various departments of public and private life; while for physicists and telegraph-engineers in particular it will have an irrestible attraction, exhibiting, as it does, though in limited space, so much that is instructive. This treasure is the historical department of the German telegraph exhibition, which places before the visitor's eye the development of telegraphy in Germany, from the earliest times to the present. It is impossible to pass through this little room without a feeling of gratitude to the authorities, learned societies, and private individuals, whose ready aid has rendered this historical collection possible. And yet how much more valuable might the collection be were the original idea of the man, who, as having been the leading organiser of this exhibition, has added another to his many services in the theoretical and practical development of telegraphy to be carried out, that of an *international* telegraph exhibition! The more reasonable is the wish that the collection here made may, as much as possible, remain unbroken, and that active efforts may be made to fill up any deficiencies. The development of telegraphy does not cover a long space of time, and several gaps in the collection might be filled without much difficulty; after which, the whole would be invaluable as material for a future History of Telegraphy.

In the following lines we propose to give some idea of this historical collection; to explain its significance to those who may be imperfectly acquainted with the history of telegraphy; to bridge over some gaps in the early history of the science; and with some side views to objects which are, or might be, shown in other parts of the great exhibition, bring down the history to the most recent times. Commencing, then, with what is earliest, we will make a few remarks on the venerable, original telegraphic apparatus, which previous to the Vienna Exhibition had been seen by but few persons now living.

In vain were the efforts made, from the middle of last century till towards the end of it, to utilise friction electricity for telegraphing. A pretty apparatus for lecture experiments might here and there be found in use, but any further practical application seemed impossible. The end of the century brought a knowledge of galvanic electricity; and in the beginning of July, 1809, M. Samuel Thomas von Sömmerring (born in 1755 at Thorn, and a member of the Munich Academy since 1805) constructed the first galvanic telegraph, in which he utilised the phenomenon first observed by Carlisle (in 1800), that the galvanic current decomposes water into its elementary constituents, oxygen and hydrogen. Sömmerring covered 27 wires with silk, so as to insulate them, formed them into a rope, and brought the gold point ends of the wires, each of which represented an alphabet letter, into a glass trough filled with water; while, at the other end of the rope, two of the wires could be connected with the poles of a voltaic battery; whereupon gas bubbles began to rise in the trough, at the two wire ends—oxygen at one, and hydrogen, in greater quantity, at the other. Sömmerring thus always telegraphed two letters at once, the letter of the hydrogen wire being regarded as the first. To announce the commencement of the process, an alarm was added, and it appears in the apparatus belonging to the Sömmerring family here exhibited.

The possibility of telegraphing with such apparatus is undoubted; and as afterwards improved by Schweigger, who reduced the number of wires to two, the telegraph would have been practically available; but as the demand for good telegraph quickly increased, better means were found of satisfying it. So that the Sommering telegraph had as little practical development as the proposal made by Prof. Coxe, of Philadelphia, in 1810, to utilise the decomposing action of the galvanic current on various salts for telegraphic signalling.

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* Abstract of a paper by Dr. Zetzche in the *Internationale Ausstellungs-Zeitung.*

The development of telegraphy took a new direction, when Prof. Oersted, of Copenhagen, in the end of 1819, made the observation that an electric current deflects a magnetic needle, when passing near it, out of its normal direction north and south. Already, in 1820, the French Academician Ampère proposed to employ the deflection of (30) magnetic needles (with 60 conducting wires) in telegraphing; but, owing to the number of wires required, the proposal, like some later ones, dropped. Next, in 1832, the Russian Councillor Schilling, of Canstadt (of German descent) sketched a telegraph with only 5 needles; later, he used only one. A drawing of his apparatus, preserved by the St. Petersburg Academy of Sciences, is exhibited. Schilling died in 1837, before his telegraph was fully completed. In 1836, however, William Fothergill Cooke saw one of Schilling's telegraphs in Heidelberg, and was induced to apply himself to the construction of telegraphs.

A telegraph on a larger scale was constructed, in 1833, by Profs. Gauss and Weber, in Göttingen, and it continued in use till 1838. At first galvanic currents were used; later, magneto-induction currents. The exhibited telegraph is the property of the Physical Laboratory in Göttingen. The needle in the receiver is a large magnetic bar, 1·21 metres long, 0·075 broad, and 0·015 thick; and the surrounding multiplier coil is enclosed by a bobbin of strong copper wire, with few turns, which acts as deadener. The needle's oscillations are shared by a small mirror, which is observed through a telescope. The sending instrument includes an induction coil enclosing a strong magnetic bar, and, by one or other of two levers, this can be moved over the bar; the connecting piece of the two levers is capable of turning about a horizontal axis, and forms part of a mercury commutator, which sends the current sometimes in the one, sometimes in the other direction, through the multiplier coil, and deflects the needle within it to the left or to the right.

The next progress in construction of needle telegraphs, viz., their transformation into writing or printing telegraphs, we owe to Prof. Steinheil, of Munich. He constructed the line (three-quarters of a mile in length), from Munich to the Bogenhausen Observatory, and telegraphed, in July, 1837, (to the latter) with the apparatus exhibited, which includes, as transmitting instrument, a magnetic inductor, capable of turning about a vertical axis, and a mercury commutator; and, as a receiving instrument, two small steel magnets turning about a vertical axis within a multiplier bobbin traversed by the induction current. Each of these magnets is furnished at one end with a small vessel of colouring matter, at the other with a metallic tongue; and they are so arranged that a current in one direction causes one of them to press with the ink vessel against a strip of paper carried along in front of it, a current in the opposite direction the other, or makes the tongues of the magnets strike on two different toned bells. The Steinheil telegraphic writing consisted of points in two different lines, these points being so grouped as to denote letters and figures. An essential advantage in the use of such writing, especially for deep sea telegraphy, lies in the fact that, for producing it, merely currents of equal length can be used. A further service was wrought by Steinheil, in 1838, in discovering the possibility of return conduction of the electric current through the earth; thenceforth only one line was required for each telegraph.

In England, Cooke, who, after his return from Germany, in 1836, had made a needle telegraph with 3 needles and 6 wires, and a pointer telegraph, united with Professor Wheatstone, and they took out a patent for a telegraph with 5 needles and 5 or 6 wires. On the 25th of July, 1837, the first trial experiments were made with it on the North Western Railway in London. In 1840 they furnished 39 miles of the Great Western Railway with their line; but on account of its great costliness (£250 to £300 per mile), the telegraph was not further extended. The needle telegraphs, constructed by Cooke and Wheatstone, with 1 and 2 needles, have continued in use up to the present. Though these telegraphs do not give an enduring signal, they yet commend themselves for many purposes, on account of their simplicity and convenient handling. Siemens's double needle telegraph (with electro-magnet) of the year 1849, is exhibited in the historical department; and one of the most recent double needle telegraphs of Siemens Brothers in London, is to be found in the English department of the exhibition.

The first pointer telegraph, in which the letter to be telegraphed is indicated by a pointer, which moves over a lettered disc, stopping opposite it, was constructed by Cooke, in 1836; and in 1840, Wheatstone greatly improved this system of telegraphy. Among the German pointer telegraphs exhibited, the latest is that made by Leonhard, in Berlin, in 1845; in the receiver of which, the electric current, by means of an escapement, sets the scape wheel (on the pointer axis) in step by step rotation, while the closing and interruption of the current in the receiver is done with the aid of clockwork. The telegraph of Drescher, in Cassel (not exhibited) had a similar arrangement. Essentially different is the pointer telegraph patented in Prussia, in 1846, by Siemens, of Berlin. This telegraph works with automatic interruption of the current, and the pointer is caused by rapidly successive making and breaking of the current to pass on to the letter to be telegraphed. This telegraph is, at the same time, the oldest exhibited printing telegraph; for it has a peculiar arrangement for printing the telegraphed letter on a strip of paper. The first type printing telegraphs were, indeed, previously constructed, in 1837, by Vail, in North America, and Wheatstone in England; also, in Germany, in 1844, the type printing telegraph transformed out of a pointer telegraph by Fardely came into use on the Taunus Railway. Of the older pointer telegraphs the historical collection only contains the pendulum which served Dr. Kramer, of Nordhausen, as relay, but unfortunately the rest of the apparatus is wanting. Copying telegraphs there are none in the historical department, but in the French Telegraphic Department may be seen two recent copying telegraphs, those of Meyer and of Gyot d'Arlincourt.

To about the same time as the needle and pointer telegraphs reach back also those of the Morse system. Prof. Morse (who died in 1872) has told us that it was in October, 1832, on his return voyage to America, the idea occurred to him of making electricity give durable and audible signals at a distance; and he also then sketched out an electro-magnetic telegraph, and a telegraphic dictionary for the signals, which were formed of dots. It was in November, 1835, he showed his friends in New York a model, differing essentially from the later Morse apparatus, and in which a zig-zag line was drawn by a pencil on a strip of paper passing before it.

The Morse writing now used consists of groups of dots and dashes, either embossed with a style, or written with colour. The electro-chemical writing, through decomposition of metallic salts in strips of paper impregnated with them, has, notwithstanding many years' experiments by Morse, Davey, Bain, and others, not come extensively into use; in the present collection are shown Gintl's chemical telegraph, and the double style apparatus of Stöhrer.

The oldest apparatus for embossed writing exhibited is Siemens's style or relief writer, dating from 1849, and so from the earliest time of introduction of the Morse telegraphs into Germany. The electro-magnet stands upright, and the lever of the armature has an arm directed downwards to which the separating spring is attached. The next oldest style writer was made by Siemens, in 1853, and came into use on the Russian lines. The lever is here connected with one core of the electro-magnet, and this core, oscillating about a horizontal axis, is prolonged, in shoe form, to the other core; thus the working of the electro-magnet is rendered quicker than that of ordinary electro-magnets. The same arrangement is seen in the electro-magnet of Frischen's style writer, 1856, for closed circuit (*Ruhestrom*). In the relief writer of Lewert of Berlin (1865), the spring barrel of the driving gear is removable, and the driving gear itself is fitted in a case, at the side of which passes the paper strip.

There is a greater variety in the construction of ink writers (black or blue). The first of these was made by Thomas John, of Prague, in 1854. In the original here exhibited, the writing wheel (fed with colouring matter from a saturated roll of felt) is fitted to a spring lever, which shares the movements of the armature lever of the electro-magnet, being connected with it by a small bar. The writing wheel is set in rotation by a cord passing from the cylinder of the paper strip. There is further exhibited a polarised ink writer, in the apparatus for submarine lines which Siemens constructed, in 1857, for the Red Sea Cable; also the first construction of polarised ink writer (patented in England in 1862) in which a small writing wheel, fitted to a slowly rotating axis with universal joint, and pressed by a lever against the paper strip, dips in an ink-holder, the level of which may be altered. The ink writer of Lewert of Berlin (1865), with removable spring barrel, has the arrangement preferred by Digner, in Paris; the writing wheel is fixedly fitted to the stand, and is slowly turned by the ink roller which is in contact with it, while the knife edge extremity of the writing lever presses the paper strip against the wheel whenever the armature is attracted. Lewert, however, has added above the ink roller, an ink-holder with valve. The other ink writer of Lewert (1868) is furnished with automatic ratchet wheel, and (as also one exhibited by Meller, of Cologne) has Brabender's arrangement of lever (1868) which is suitable either for the working current or the closed circuit system. The older arrangements of the kind by Wiehl and Dehms one misses in the historical department; the most recent have been exhibited by M. Schäffer, in Vienna, in the Pavilion of Commerce and Palace of Industry. The polarised quick ink writer of Siemens (1868), lastly, is characterised by an arrangement which permits of varying, within wide limits, the rate of paying out the strip of paper. The department does not contain any ink writer of the kind devised by G. Wernicke, in Berlin, in which the ink passes through a capillary tube to the paper from a holder fixed to the lever, unless we here reckon the ink writer exhibited by the Bavarian telegraph authorities, in which the paper strip is moved by the lever against a fine orifice at the lower end of the ink-holder. Another Bavarian ink writer again, with knife-edge on armature-lever, presents a new mode of transmitting rotatory motion to the little wheel. We may here refer to the peculiar ink-holders, serving at the same time as writing wheels, that are exhibited in the French department.

There have not been wanting, also, experiments to group dashes and dots distributed in two lines according to a telegraphic code. The electro-magnetic double style apparatus devised by Stöhrer, of Leipsic, came into use in Saxony, in Bavaria (1849-58), and, experiment-wise, in Austria, but, notwithstanding its simple and short writing, had to give way to the Morse apparatus. The department exhibits one of Stöhrer's double style apparatus of the oldest construction (with polarised relay belonging to it), and there is another quite similar in the Bavarian department; also, in the latter, a new double style writer, with four different relays (with movable plates, with two constant steel magnets, with two horse-shoe magnets, with six bar magnets); in the general department, on the other hand, we find Siemens's alterations—a double style relief writer (1850) with the oldest form of polarised relay (without steel magnets; the armature magnetised inductively from the core of an electro-magnet, with branch current from local battery circulating round it), and a key board with 30 keys, as also a polarised double style relay with steel magnets (1852).

It has lately been proposed (1872) to return to the Steinheil writing, which consists only of dots distributed in two lines, but with this difference, that with a suitable punching arrangement the points be punched in the paper. Apparatus of this kind are exhibited by Jaite and Gurlt, of Berlin.

There are no copying telegraphs in the German exhibition, for no German has made such a telegraph.

Of type printing telegraphs, the historical department contains, besides that of Siemens's already referred to, only Hughes's apparatus as made in Germany, and an insertion for Hughes's end and translation stations; the French exhibition, on the other hand, shows the type-printing telegraphs of d'Arlincourt and Dujardin, of Lille, each of which is fitted with two type wheels. The newest type-printing telegraph, that of Siemens, only arrived in Vienna about the middle of August. The Börsen telegraphs, finally, of O. Schäffler and A. Bauer (in the Austrian department of the Palace of Industry) are also type-printing telegraphs, but they require two or three lines.

Alarum apparatus for railways is only represented, unfortunately, by one of the oldest, that of Siemens's (1847), in which a hammer is raised and falls back of itself. The importance of bell apparatus for railways appears in other parts of the exhibition.

Of the efforts which have been made to utilise the same telegraph line for the simultaneous transmission of several telegrams (duplex telegraphy), we are reminded, in the historical department, only by Frischen and Siemens's relay with double coils, and oscillating magnet, for duplex signalling (patented in Prussia in 1834), and a relay with double coils by Borggreve. In this respect, therefore, the collection is very deficient; for most of the proposals in this direction have been made by Germans. It is also to be regretted that the recent successful experiment in duplex telegraphy by Preece in England has not been exhibited, and that of telegraph apparatus in England generally only those of Siemens Brothers are shown. From Hungary we have the duplex system of Franz Kosmata, in Pesth (1869). And we may here lastly notice the method (closely related to double telegraphy proper), first brought out in 1851, in which, on one and the same line, several telegrams are transmitted alternately in fragments (that is, the signals of the two telegrams alternating). The most suitable of apparatus for this purpose is that recently constructed by B. Meyer, in Paris, which was practically tested from 18th July to the 10th August, on a half-mile line from the Palace of Industry (French department) to the central telegraph office, and with good results, which allow of the hope that it may be practically serviceable on longer lines. Another experiment towards solution of the same problem was made by A. Bauer, in Vienna, whose apparatus (*Illimit Apparat*), not quite completed, unfortunately, and by no means simple or readily intelligible, appears in the Pavilion of Commerce. Both apparatus require, of course, synchronism between the two stations.

(To be continued).

TELEGRAPHIC WIRES.—According to the official account on exports, the value of telegraphic wires and apparatus forwarded from the United Kingdom last year had increased to £2,359,563 from only £405,318 in the previous year.

EXTRACTS FROM REPORTS ON THE PRACTICABILITY OF MAKING AND LAYING A LIGHT CABLE ACROSS THE ATLANTIC, AND ON HIGHTON'S PATENTS.

W. H. **Preece**, Esq., C.E., Engineer of Post Office Telegraphs:—"The teachings of experience, as well as the progress of scientific thought, have tended not only to vary the form, but lighten the weight and cost of deep-sea cables. The present cables which span the Atlantic possess elements of decay which must interfere with their durability, and ultimately prevent the possibility of their repair. The cable that you have submitted to me is in my opinion superior to these and to any other form that I have seen for deep-sea purposes; it is easier to lay, more durable, and more efficient. Its strength and lightness are admirably adapted for future raising in the event of repair. Its construction prevents the possibility of those accidents which nearly proved fatal to the present cables during the process of laying. Its size and lightness enable it to be coiled with great ease in small tanks, prevent its kinking, and render the operation of paying out a comparatively easy one. Hence only an ordinary ship and simple machinery are needed for its submersion. Having designed and superintended the construction of the Channel Islands Cable in your works, I am ready to testify to their special fitness for the construction of the proposed light cable; the ship being able to come alongside in the docks is a great advantage. With regard to Mr. Highton's new receiving apparatus, I must express my surprise at what I saw; signals that were completely invisible on ordinary instruments were rendered easily readable by its means. There is no doubt that the more we increase the sensitiveness of our recording instruments, the more rapid (*cœteris paribus*) the rate of working through long cables. Hence Mr. Highton's instruments enable us to obtain the same rate of working upon a much cheaper core. The electrostatic capacity of the core you propose to use is less than that of the existing Atlantic cables, but its resistance is greater. This extra resistance is, however, compensated for by the novel apparatus proposed for use. It also appears to me that Mr. Highton's apparatus is less liable to disturbance from those cosmical causes that interfere so much with the working of long cables with the ordinary modes of working."

J. **Bourdeaux**, Esq., Chief Electrician and Engineer to the Submarine Telegraph Company:—"I had the opportunity yesterday of seeing Mr. Highton's inductive arrangement for the multiplication of a current at the receiving end of a cable, and was greatly surprised at the results obtained. An ordinary galvanometer, the mechanical structure of which was very imperfect, was placed at the end of a circuit of great resistance—26,000 ohms—and when a current was passed through this circuit in the usual way, no movement of the galvanometer needle was visible. Upon the induction coil being introduced, however, the results were astonishing; signals sufficiently strong for ordinary working purposes were received. Upon connecting with Mr. Highton's extremely sensitive gold-leaf instrument the effect was far greater, showing naturally that, with conditions more efficient than those used in the first examination, a more satisfactory result could be obtained. The importance of being able to multiply the current at the receiving end of a wire is evident, a smaller conductor for a long cable being rendered practicable, with at least the maintenance of the speed at present obtained upon the long cables now working. The pattern of the proposed cable is an element of the greatest importance. Tests have, I am informed, been carried out relative to the strength, as shown by breaking strain, and are particularly satisfactory. The lightness of the completed cable is such that the matter of submergence becomes one of less cost and greater facility—less cost, on account of the size and expense of the vessels needed to lay such cables, and greater facility, on account of the ease with which they can be handled and coiled in ships' tanks."

R. S. **Culley**, Esq., Engineer-in-Chief, Government Postal Telegraphs:—"I have witnessed the experiments named in Mr. Bourdeaux's letter to Mr. Bullivant, and can certify that he has described their result correctly."

Captain V. F. **Johnson**, R.N., Surveyor for the French Atlantic Cable of 1869:—"There can be no doubt that it is just as easy for a steamer of sufficient size to lay the light cable as it would be for the *Great Eastern* to lay the heavier ones which she has already accomplished. It quite depends upon the perfection of the mechanism for paying out the cable. If the *Great Eastern* was steaming four miles per hour, and the cable was checked, it would certainly be carried away, even if it was the strength of her iron chain cable. I am most decidedly of opinion the cable is much more likely to last, when laid, than those cables protected by iron wire. I may mention that I have sounded from Plymouth to Malta, Gibraltar to Valencia, Bombay to Aden, and from thence through the Indian Ocean, round the Cape of Good Hope to England, as well as the line of soundings taken for the French cable of 1869, and have never found a ridge that would endanger any cable. The bottom of the ocean is composed of most minute shells which can only be distinguished by a microscope; it looks to the naked eye like a very fine impalpable powder, therefore peculiarly adapted for the preservation of a cable when once laid."

G. E. **Preece**, Esq., of the Government Postal Telegraph Engineering Department:—"I have much pleasure in replying to your letter of the 25th July, respecting certain points in connection with the samples of light deep-sea cable you submitted to my notice. From the specimen of cable you have shown me, and the details I have obtained of its component parts, I will now only refer to the two main questions—the mechanical and the electrical. By the mechanical I mean such points as involve the construction or manufacture, the shipment, submersion, and probable duration of the cable, not forgetting the suitability for effecting repairs. The diameter and weight of the completed cable play a most important part in the economy of submersion; the small size and weight allowing the employment of a moderate sized vessel for the stowage of the deep-sea cable. This is an important point, as it is most essential for deep-sea cable work that no transfer should be made from ship to ship. The facility for the coiling of such a cable is very great—its pliability being undoubted, and the ease and freedom with which it can be coiled will facilitate operations. The paying-out will be a matter of ease, the light weight of the cable and its small specific gravity will necessitate the use of but small paying-out gear, requiring but little retarding force. The enormous breaking strain of the cable compared to its weight speaks most favourably for the facility of lifting in deep water, should such an operation be necessary, and I can see no difficulty in the operation considering that really heavy cables have been lifted from depths over 2000 fathoms. With regard to the speed of working with such a core of which you have given us a specimen, and the weight of which is—

Copper	108 lbs.	per nautical mile.
Gutta-percha..	166 lbs.	,,

I have gone very carefully into the matter, and have made many calculations from known data. I anticipate on a length of 2000 miles of this core an actual speed of *ten* words per minute. The calculations for speed of working are based principally upon the results obtained from the existing American cables between Ireland and Newfoundland, and the system of working is known as the Mirror System, with the use of condensers—a very material point in long submarine cables, as their use neutralises the disagreeable effects that are generally derived from 'earth currents.'"

"From the result of the experiments shown me by Mr. Highton, I am quite satisfied that by the use of an induction coil, arranged in the manner I saw, that he is able to increase the strength of the signals at the receiving end of a line, and to such an extent that a very weak signal may be increased to work his gold-leaf instrument, or other instruments at present in use; the amount of the multiplication of the signals depending on the proper apportionment of the lengths and resistance of the primary and secondary wires or instruments producing induction. In the experiments I witnessed, I observed that, when a signal was rendered invisible on an ordinary instrument by the addition of increased resistance to the circuit, the insertion of Highton's induction coil at once made the signals strongly visible, the amount of increase in strength being surprisingly large. By the use of the induction coil, and the present arrangement, it is possible to catch the electric wave at a point whose potential would be less than that required to work the present form of instruments, and thereby an increase of speed may be gained. According to the amount of speed thus gained, a proportionate decrease could be made in the size of the core of a submarine cable to maintain the existing rate of speed. I am quite satisfied that, with the arrangements proposed for working the cable by the use of induction coils at the receiving end, no interference to working will be experienced from the presence of earth currents."

CROMWELL F. VARLEY, Esq., F.R.S.:—"The object of the steel and hemp covering of the three long deep-sea cables which have been successfully submerged across the Atlantic, is simply to enable the engineers to lay the insulated conductor uninjured at the bottom of the ocean. The Atlantic cables with their hemp and steel are so heavy that they will not support a greater weight than ten miles of their own length in water. Experience has shown that, excepting in very smooth water, this strength is insufficient to allow of a cable being hauled in again in case of accident. The light cable will support more than thirty miles of its own weight in water. The three faults which jeopardised the French Atlantic cable were punctures through the gutta-percha destroying the insulation of the conductor. All these three had the appearance of being caused by the pointed end of a scarf joint in the steel wire. As no steel or iron wire is used in the light cable, this kind of fault cannot be produced. The steel wire gives a great amount of springiness to the cable, and consequently a great tendency to produce foul flakes, which result in frightful tangles, which cannot pass the paying-out machine. These heavy cables are also very liable to kink, and it is only by the most praiseworthy watchfulness and courage on the part of the well-trained staff in the tanks that these disasters are prevented from being numerous. The light cable, even when purposely coiled irregularly, clears itself—a property not possessed by any form of iron-clad cable. It is so light that no paying-out machinery at all is required to hold it back, consequently should kink, foul flakes, or tangles be made, they would simply go overboard and do no harm whatever. No men will be required in the tanks during the paying-out—an important safeguard against injury. In water, this cable is so light that, even in the greatest depths of the Atlantic, two men could haul it back. The light cable does not require enormous vessels for its transport, and the cost of laying is very much reduced in consequence. In a word, the light cable avoids the chief difficulties and risks common to the heavy cables, and, as no break power is required to hold it back, it will never receive any strain during its submersion. It further admits of being grapnelled for and safely recovered from much greater depths than those found between Europe and America."

Students' Column.

Resistances and their Measurement.—By H. R. KEMPE.

VI.—The internal resistance of batteries can be determined in one or two other ways besides those shown in our last article; but as these methods involve principles which we have not yet discussed, we shall defer their consideration to a later period. Our next undertaking will be the—

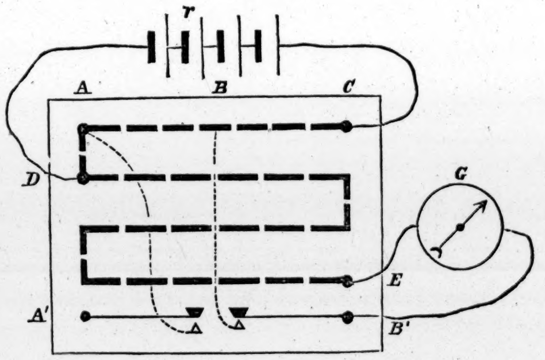
Comparison of the Electromotive Forces of Batteries.—This subject, though not coming precisely under the head of "Resistance Measurement," nevertheless, as it is involved in it, may be included under that head.

The methods of comparing the electromotive forces of batteries are perhaps more numerous than any other class of measurements. We shall consider the principal methods.

As no absolute standard of electromotive force exists, we cannot directly determine the electromotive force of any particular battery in terms of the standard unit (the *volt*), but can only compare the relative electromotive forces of two or more batteries.

First method:—Suppose we have two batteries, A and B, whose electromotive forces are to be compared. Join up battery A with a galvanometer and resistance-box in simple circuit, as shown in Fig. 8

FIG. 8.



All the plugs between A and C being inserted, and the infinity plug between A and D being removed; the connections being made, depress the right-hand key, and remove a sufficient number of plugs from between D and E, to obtain a convenient deflection on the tangent scale of the galvanometer. Note this deflection—let it be *d* divisions; and also note the *total* resistance (R) in circuit,—that is, the resistance between D and E, plus the resistance of the galvanometer, plus the resistance of the battery (which must be determined beforehand). Now remove battery A and insert battery B in its place, and, if this battery have a different resistance to A, re-adjust between D and E so that total resistance in circuit is the same as it was at first. Again note the deflection of the galvanometer needle—let it be d_1 divisions. Then electromotive force of A will be to electromotive force of B as d is to d_1. For calling E the electromotive force of A, and E_1 the electromotive force of B, then—

$$I=\frac{E}{R} \text{ and } I_1=\frac{E_1}{R},$$

therefore—

$$E : E_1 :: I : I_1,$$

and d and d_1 are directly proportional to I and I_1.

Example.—With a tangent galvanometer, whose resistance is 100 ohms, and battery A, whose resistance is 70 ohms, we obtained, with a resistance of 1830 ohms (total, 100+70+1830=2000), in the resistance-box, a deflection of "50" divisions on the tangent scale of the galvanometer; and with battery B, whose resistance is 50 ohms, we obtained, with a resistance of 1850 ohms (total, 100+50+1850=2000, as before), in the resistance-box, a deflection of "40" divisions; then—

$$\text{E.M.F. of A : E.M.F. of B} :: 50 : 40$$
$$\text{or as } 5 : 4.$$

(E.M.F. = electromotive force).

If the resistances of the batteries whose electromotive forces are to be compared are very small, we may, by using a very high resistance, practically regard the total resistance in circuit as the same, whatever battery we use. The deflections then obtained with any number of different batteries will represent their comparative electromotive forces. The galvanometer will, of course, have to be a comparatively sensitive one.

Second method:—Join up as in last method, and having noted the deflection and total resistance in circuit (R) with battery A, remove it, and insert battery B in its place. Now re-adjust resistance between D and E, until the deflection of the galvanometer needle becomes the same as it was at first. Note the resistance in circuit (R), then—

$$I=\frac{E}{R} \text{ and } I=\frac{E_1}{R_1},$$

that is,—

$$E : E_1 :: R_1 : R,$$

or the electromotive forces of the batteries are *inversely* as the total resistances that were in circuit with the respective batteries.

Example.—With a galvanometer whose resistance is 100 ohms, and battery A whose resistance is 70 ohms, we obtained, with a resistance of 1830 ohms (total, 100+70+1830=2000), in the resistance-box, a deflection of 40°; and with battery B, whose resistance is 50 ohms, it was necessary, in order to bring the galvanometer needle again to 40°, to have a resistance of 2350 ohms (total, 100+50+2350=2500), in the resistance-box; then—

$$\text{E.M.F. of A : E.M.F. of B} :: 2500 : 2000$$
$$\text{or as } 5 : 4.$$

Third method:—In Fig. 8 join the zinc pole of battery A to D, as shown, and the other pole to the zinc pole of battery B, whose other pole in turn is to be joined to C. Adjust resistance so as to obtain a high deflection on the tangent scale of the galvanometer—let it be d divisions; then—

$$I=\frac{E+E_1}{P},$$

where P is the total resistance in the circuit. Now reverse battery B (the weaker one) so that the two oppose one another,—we shall then get a smaller deflection of d_1 divisions; then—

$$I_1=\frac{E-E_1}{P}.$$

From these two equations we get—

$$EI-E_1I=EI_1+E_1I_1,$$

that is,—

$$E : E_1 :: I+I_1 : I-I_1,$$

or, substituting deflections for intensities,—

$$E : E_1 :: d+d_1 : d-d_1.$$

Example.—The two batteries A and B being joined up together in simple circuit, we obtained, by adjusting resistance in resistance-box, a deflection (d) of 72 divisions on the tangent scale of the galvanometer; and with the same resistance in circuit we obtained, on reversing battery B, a deflection (d_1) of 8 divisions; then—

$$\text{E.M.F. of A : E.M.F. of B} :: 72+8 : 72-8,$$
$$\text{or as } 80 : 64,$$
$$\text{that is, as } 5 : 4.$$

Fourth method:—The most elegant method of comparing the electromotive forces of batteries is that of Sir Charles Wheatstone. One of the batteries, A, whose resistance we will call r, is joined up in simple circuit with a galvanometer whose resistance is G and a resistance R in the resistance-box. A deflection of $\alpha°$ is obtained; then (substituting deflections for intensities)—

$$\alpha°=\frac{E}{R+r+G}. \quad . \quad . \quad (1)$$

R is now increased by ρ, and a new deflection, $\beta°$, is obtained; then—

$$\beta°=\frac{E}{R+\rho+r+G}. \quad . \quad (2)$$

Battery A is now removed, and battery B, whose resistance is r, substituted in its place. The resistance-box is then adjusted to R_1, so that deflection becomes $\alpha°$ as at first; then—

$$\alpha°=\frac{E_1}{R_1+r_1+G}. \quad . \quad . \quad (3)$$

R_1 is now increased by ρ_1 until deflection becomes $\beta°$; then—

$$\beta°=\frac{E_1}{R_1+\rho_1+r_1+G}. \quad (4)$$

From equations (1) and (3) we get—

$$\frac{E}{(R+r+G)}=\frac{E_1}{R_1+r_1+G},$$

or—

$$\frac{R+r+G}{E}=\frac{R_1+r_1+G}{E_1}, \quad (5)$$

and from (2) and (4)—

$$\frac{E}{\rho+R+r+G}=\frac{E_1}{\rho_1+R_1+r_1+G},$$

or—

$$\frac{\rho}{E}+\frac{R+r+G}{E}=\frac{\rho_1}{E_1}+\frac{R_1+r_1+G}{E_1}.$$

Substituting the value of—

$$\frac{R+r+G}{E},$$

from equation (5), on the right-hand side, we get—

$$\frac{\rho}{E}=\frac{\rho_1}{E_1}.$$

or—

$$E : E_1 :: \rho : \rho_1.$$

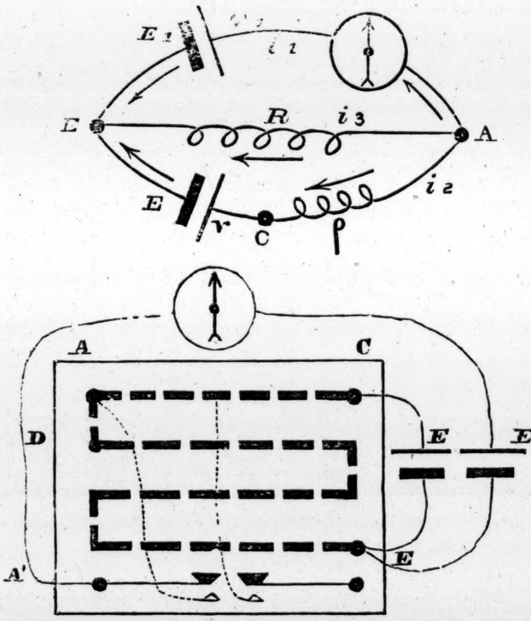
That is to say, the electro-motive forces of the batteries are directly proportional to the added resistances which, in both cases, were required to bring the deflections of the galvanometer needle from α° down to β°.

Example.—With a galvanometer and battery A we obtained, with a resistance of 1830 ohms in the resistance-box, a deflection of 40°, and by adding "300 ohms," a deflection of 34°. Battery B being inserted in the place of A, a resistance of 2350 ohms was inserted in the resistance-box, which brought the galvanometer needle to 40° as at first, and by adding "240 ohms," the deflection was reduced to 34° as at first. Then—

E.M.F. of A : E.M.F. of B :: 300 : 240
or as 5 : 4

In all these methods of comparing electromotive forces, action goes on in the batteries whilst the measurements are being made. Now certain batteries, the Marie Davy and Leclanché for instance, show a considerable falling off in power when continuously worked. If, therefore, it is required to compare the electromotive forces of such batteries when they are not in action, we must adopt some method in which, by a peculiar arrangement of resistances, one battery is made to balance the other. One of these methods is that of Kirchoff. Fig. 9 shows the theoretical and practical way of making this test.

Fig. 9.



The theory of this method is best explained by the two of Kirchoff's laws, which, though exceedingly simple and easy of application, are not so well known as they ought to be. We will therefore briefly state them:—

1.—*The sum of the intensities in all those wires which meet in a point is equal to nothing.*

2.—*The sum of all the products of the intensities and resistances in all the wires forming an enclosed figure equals the sum of all the electromotive forces in the same circuit.*

In the figure, E and E_1 are the batteries to be compared. R and ρ are adjustable resistances, r and r_1 being the resistances of the batteries. Before equilibrium is obtained, we have from the above laws—

$$(r+G)i_1+Ri_3-E_1=0 \quad (1)$$
$$(r_1+\rho)i_2+Ri_3-E=0 \quad (2)$$
$$i_1+i_2-i_3=0$$

ρ being any resistance, R is adjusted until the needle of the galvanometer is brought to zero, that is, until—

$$i_1=0, \text{ which makes } i_2=i_3.$$

These values being substituted in equations (1) and (2), we get—

$$Ri_3-E_1=0 \text{ or } i_3=\frac{E_1}{R}$$

and—

$$i_3(r_1+\rho+R)-E=0$$

therefore—

$$\frac{E_1}{R}(r_1+\rho+R)-E=0$$

or—

$$E : E_1 :: (r_1+\rho)+R : R.$$

It will be observed that in order to get the ratio of E to E_1 from this proportion, we must know the resistance r_1 of battery A. If, however, we change ρ to ρ_1, and again get equilibrium by re-adjusting R to R_1, we get a second proportion, viz.:—

$$E : E_1 :: (r+\rho_1)+R_1 : R_1.$$

Combining these two proportions, r is eliminated, and we get—

$$E : E_1 :: (R-R_1)+(\rho-\rho_1) : (R-R_1)$$

a proportion in which differences of resistance alone enter. In fact $(R-R_1)$ and $(\rho-\rho_1)$ are merely the resistances which we *subtracted* (for R is greater than R_1 and ρ than ρ_1) from the two branches in order to get equilibrium a second time. We have, therefore, only first to get equilibrium with any resistances we please, and then to subtract a resistance from one of the branches, and again get equilibrium by subtracting a resistance from the other. The electromotive forces of the batteries will then be in the proportion of the larger subtracted resistance to the sum of the two subtracted resistances.

Example.—Two batteries, A and B, whose electromotive forces, E and E_1, are to be compared, are joined up in circuit with a galvanometer and two resistances, as shown in Fig. 9. The resistance ρ being 200 ohms, it was necessary, in order to produce equilibrium, to make R=1080 ohms. ρ was then reduced by "100 ohms," and in order to again produce equilibrium, R had to be reduced by "400 ohms." Then—

E.M.F. of A : E.M.F. of B :: 400+100 : 400
or as 5 : 4

In making this test practically, having made the connections as shown in the figure, and seeing that both the infinity plugs are firm, we should depress the left-hand key, and then, according to the example, we should take out the two 100 plugs between A and C, and proceed to adjust between D and E. This being done, we should replace one of the 100 plugs between A and C, and then proceed to adjust again between D and E, carefully taking note of what resistance we subtract to again produce equilibrium. The electromotive forces of the batteries are then as shown in the example.

(To be continued).

PAPERS FOR JUNIOR STUDENTS.

Formulæ Analysed.—By Arthur R. Granville.

II.—In my former paper I referred to *conductivity* as being the converse of *Resistance*. The specific conductivity, or reciprocal, of a conductor does not at first sight seem to strictly bear that definition. From a casual inspection the general formula $\frac{a}{b}\ 100$ appears to be simply the comparison of a conductor with another of pure copper (whose conductivity is represented by 100), and is determined by *the ratio of their resistances*. That such is the case and for what reason will be shown further on. Let us bear in mind that, if we adhere to the pure scientific meaning of the word conductivity, as the reciprocal of resistance, specific conductivity as accepted is not strictly a reciprocal of resistance, although based upon it. It is this apparent dissimilarity of terms which puzzles many students.

a. One of the practical uses in telegraphy of conductivity which *is* the reciprocal of resistance is to obtain the measurement of the joint resistances of two or more wires. Take, for instance, two lines whose resistances are R and r. Their reciprocals are, therefore, $\frac{1}{R}$ and $\frac{1}{r}$; and the sum $\frac{r+R}{Rr}$, their joint conductivity; whilst its converse $\frac{Rr}{r+R}$ is the joint resistances: such is the formula for finding them. In like manner the total resistances of any number of wires—

$$a, b, c, d\ .\ .\ .\quad x = \frac{a\,b\,c\,d\ .\ .\ .\ .\ x}{a+b+c+d\ .\ .+x}$$

With a fault on a line, and with the above formula, it becomes an easy matter to calculate the amount of current wasted at the fault, and, consequently, the amount of balance which will reach the receiving station. Let—

$f =$ resistance of fault
$r =$ " " line from the fault to the distant station

then we have $\frac{rf}{r+f}$, the combined resistances. Following Ohm's law, the current C, from the battery whose electromotive force is E, is represented by—

$$C = \frac{E}{R+\frac{rf}{r+f}} = \frac{E\,(r+f)}{R\,(r+f)+rf}\ .\ .\ .\ .\ .\ (1)$$

in which R is the resistance of the line from battery to the fault, as well as the internal resistance of the battery itself together with that of the instruments. Now the resistances under analysis being r and f, their conductivities are represented by $\frac{1}{r}$ and $\frac{1}{f}$, or reducing them to the same denominators $\left(\frac{f}{r+f}\right)$ and $\left(\frac{r}{r+f}\right)$ respectively. Hence the portion of the current leaking out at the fault may be written—

$$C\left(\frac{r}{r+f}\right) = \frac{r}{r+f}\cdot\frac{E\,(r+f)}{R\,(r+f)+rf}$$

$$= \frac{Er}{Rr+Rf+rf}\ .\ .\ .\ .\ (2)$$

whilst the balance of the current arriving at the distant end will be—

$$C\left(\frac{f}{r+f}\right) = \frac{Ef}{Rr+Rf+rf}\ .\ .\ .\ .\ .\ (3)$$

Thus we obtain equations (2) and (3), both of which are formulæ in Mr. Culley's "Handbook of Practical Telegraphy," for determining the rule of the division of a current where a fault occurs.

β. The general formula as mentioned above, for obtaining the specific conductivity of a line, is $\left(\frac{a}{b}\ 100\right)$, in which $a =$ the resistance of the standard of pure copper, whilst $b =$ that of the line under consideration. That specific conductivity cannot bear the precise interpretation which scientists define conductivity to mean is evident for it then would be $\frac{1}{b}$, and not $\left(\frac{a}{b}\ 100\right)$. But the adjective SPECIFIC modifies the meaning into *Comparative or Relative Conductivities*. Hence, though in one sense not a reciprocal, yet it is a comparison of reciprocals measured by a general standard, 100. In the general formula the two measurements are a and b; their conductivities are $\frac{1}{a}$ and $\frac{1}{b}$; their comparisons with the standard 100 assume the following proportionals—

$$\frac{1}{b} : \frac{1}{a} :: x : 100.$$

$$= \left(\frac{\frac{1}{b}}{\frac{1}{a}} = \frac{x}{100}\right)$$

$$= \left(\frac{a}{b} = \frac{x}{100}\right)$$

$$x = \frac{a}{b}\ 100.$$

From this it is evident that the required specific conductivity x is obtained upon the basis of the comparison of the reciprocals, though expressed in figures approaching nearer to 100, according to the purity of the conductor.

The quantity x is a variable function of $\left(\frac{a}{b}\right)$ 100, whose variation is dependent on the value of b, and it approaches nearer to 100 in proportion as the two resistances are equal. In a healthy cable x should remain constant, omitting trifling exceptions, with its value when the cable was manufactured or laid, otherwise a faulty insulation may be looked for. All variations do not, however, betoken faulty insulation; for should b become permanently $b' > b$, then the extra resistance may be the result of dirty or imperfect connections, and may easily be remedied. Earth currents opposing that of the battery may likewise produce extra resistance, so that $b' > b$; but earth current resistances are exceedingly inconstant, and their nature may be easily calculated.

When the cable is unhealthy from a faulty insulation, its normal copper resistance is lowered, and $b' < b$. Consequently the specific conductivity approximates closer to 100 in proportion as $\frac{a}{b'} > \frac{a}{b}$, and indicates apparently improved conductivity, which is, however, a sign of faulty insulation.

For small tests the formula $\frac{0{\cdot}1516\ l^2}{br}$, founded on that of the resistance of small lengths explained in the last paper, is most serviceable. For 0·001516 equals the resistance of pure copper, and takes the place of a in the general formula; to which we may adapt it by writing it in the form $\left(\frac{0{\cdot}001516}{b}\ 100\right).\frac{l^2}{r}$, where the portion in brackets is $\left(\frac{a}{b}\ 100\right)$.

Errata.—Page 88, line 25 from bottom, *read* "and *the result is* the coefficient" &c. Line 28 from top, 2nd col., for e in the formulæ read l.

(To be continued.)

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

An ordinary meeting of this Society was held on Wednesday evening, the 11th inst. In the absence of the President the chair was taken by Mr. C. W. Siemens, C.E., F.R.S., &c., Vice-President.

A paper on "*Torpedo Warfare*" was read by Mr. Nathaniel Holmes, and was followed by a discussion, in which Professor Abel, Captain McEvoy, of the United States, and Mr. E. O. Brown took part.

An abstract of the paper and a report of the discussion will appear in our next issue.

The author has engaged to contribute a further paper on the same subject.

Correspondence.

WEATHER TELEGRAPHY.

To the Editor of the Telegraphic Journal.

Sir,—The last number of your excellent journal contains a very interesting article on the Origin of Telegraphic Meteorology. The author of the article attributes the honour of the introduction of telegraphic meteorology into France to M. Le Verrier. This is a great mistake. M. Le Verrier, who is now very friendly towards meteorology, was one of its greatest enemies up to the time that M. Emmanuel Liais, titular astronomer of the Observatory of Paris, which he had entered at the same time as M. Le Verrier, had convinced him by his interesting work on the storm in the Black Sea, in November, 1854, of the storm of Balaklava. It is M. Emmanuel Liais who brought to the Paris Observatory the idea of telegraphic meteorology, and who developed it there by his labours. To him, then, belongs the entire honour, so far as France is concerned. At the same time, Mr. Piddington had started the same project at Calcutta, following the example of the United States of America, where the idea was first put into execution.

I have not the honour of knowing M. Liais personally, I have then no personal interest in constituting myself his champion. It would, however, certainly be an act of justice if you would rectify the mistake made in the article mentioned.—I am, &c.,

P. Werdepmann.

4, Princes Street, Stamford Street,
London, S.E., Feb. 9.

Electrical Science in Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxviii., No. 3.

Memoir on Temperatures Observed in the Jardin des Plantes during 1873, *with Electric Thermometers to* 36 *Metres Depth.* (Extract).—MM. Becquerel.—For some years past a number of thermometers have been placed in the gardens for observation of the temperature of air above the ground to a height of 20 metres, and at various points underground to the depth stated. The buried thermometers are very durable; the cables composing them are surrounded with gutta-percha, then enclosed in tubes of sandstone filled with concrete, which tubes are introduced into pits also filled with concrete. It is found that, under turf-covered ground, the temperature, to a few decimetres below the surface, is higher at 6 a.m. than at 3 p.m. under bare ground, and that at 3 p.m. the contrary is the case; while the mean annual temperature is nearly the same in both kinds of ground.

On the Discovery of a Bed of Bismuth in France.—M. Carnot.

Vibratory Movement of an Elastic Wire attached to a Tuning Fork.—M. Grisson.

Measurement of the Magnetic Moment of very small Magnetic Needles.—M. Boutz.—The principle of the method is this: Conceive a rigid support movable about a vertical axis. Fix to this support (1) a horizontal needle with known magnetic moment M, (2) a needle whose magnetic moment x is to be determined. The two needles are placed one above the other, with their axes at right angles, and are so far apart that their reciprocal action does not alter the distribution of magnetism in either. This system, under terrestrial magnetism, takes a certain position of equilibrium, such that the magnetic axis of the needle M makes with the plane of the magnetic meridian an angle a determined by the equation $x = \mathrm{M} \tan a$. If the moment x is small enough in proportion to M, the angle a may be accurately determined by the optical method of Gauss and Weber. For this end, the support of the needles carries a little vertical mirror, in which the image of a scale is observed through a telescope. The moment M of the directive needle may be made as weak as one chooses. Hence the method may serve for measurement of the magnetic moment of very small needles (*e.g.*, 1 to 2 mm. long and 0·2 mm. diameter, with which the author succeeded). In practice, the support of the needles is a bar of wax, suspended by a silk fibre.

No. 4.

Various Reactions of Oxygenated Compounds of Nitrogen.—M. Berthelot.

Acetylen Liquefied and Solidified by means of the Electric Effluvia.—MM. P. and Arn. Thenard.—The gas was condensed very rapidly—4 to 5 cubic centimetres in a minute,—the interior walls presenting a solid substance of vitreous or rather horny appearance, very hard, and with the colour of wine. Analysed, it gave exactly the elementary formula of gaseous acetylen. It has hitherto proved refractory to all solvents, even fuming nitric acid. The authors had not yet distilled it, but they expect the body obtained is of bitumen or a like substance.

Note on Magnetism. (Paragraphs 58-61).—M. Gaugain.—With regard to distribution of magnetism in a bar having bobbins, traversed with currents at its two ends (lately studied by M. Jamin), the author found that if the magnetism be measured by means of induction currents, the results quite conform to the theory of solenoids. He seeks to reconcile the theory with the attraction-phenomena which M. Jamin observed.

Recurring to the phenomena which follow detachment of the armature, the author finds, in addition to the singular fact mentioned in last note, that the magnetism obtained in an iron bar from a determinate current may be strengthened by a current of contrary direction. This is how he operates:—He first passes a current +I through the bobbins of an electro-magnet furnished with its armature interrupts; the current without detaching armature; passes a current of contrary direction and less intensity, $-i$, interrupts this current; detaches armature; applies and detaches it again a number of times sufficient to bring the magnetism to the constant state. At the end of this process, the persistent magnetism is found to be much stronger than if only the current +I had circulated in the bobbins. He explains this fact on the same principles as the previous one. He next examines a case in which a bar magnetised in two different ways gives the same induction currents, and yet the magnetic states are not the same, and makes some theoretical remarks on magnetisation with currents of different intensities.

The Rupture of Magnetic Needles.—M. Bouty.—A magnetised needle (of recently hardened steel) being broken in the middle, one or other of two cases may occur:—1. If the needle is so hardened as to break in the fingers like glass, the two halves are magnets, having the same magnetic moment; 2. If the steel is less hard, so that it is bent several times in opposite directions before breaking, the two halves have unequal magnetic moments, (and, it seems at first, arbitrarily so). Some experiments throw light on this difference. A soft needle, being pinched in the middle, and one half seized with the hand, bent backwards and forwards till rupture, the bent half is found with less magnetic moment than the other. A similar needle being seized with two pincers at two points very near the middle (and equally distant from it), and bent to and fro till rupture, the two halves show equal magnetic moments. It is inferred that rupture does not itself produce magnetic effect, independent of the separation, pure and simple, of the parts, at least so far as it is not accompanied with flexions affecting a finite portion of the broken needle. The author discusses three cases, rupture of saturated cylindrical needles perpendicularly to the axis; rupture of unsaturated cylindrical needles; rupture of saturated needles parallel to the axis. In the last case (prismatic bundles being first made up of strips of watch-spring, hardened and magnetised) the separated laminæ were found not saturated, and, what seemed strange at first, the sum of the magnetic moments of the separated laminæ was considerably greater than the magnetic moment of the original bundle. This the author will examine in a future note.

Les Mondes. Vol. xxxiii., No. 5.

This number contains no original papers relating to electricity.

Journal Telegraphique, Vol. ii., No. 23.

Telegraphy at the Vienna Exhibition (*Continued*).—This paper treats of submarine and subterranean telegraphy, and the progress made in it since the Paris Exhibition. After noticing the extension of the submarine system, and the mode of conduction of several cables, the writer gives an account of M. Tommasi's hydro-electric cable. The French Government have authorised the laying of a cable of this kind between France and Corsica.

No. 25.

Third Note on the Best Dimensions to give Electro-Magnets.—M. du Moncel.

Results of the Introduction of Urgent Telegrams into the Service of the Netherlands.—M. Linckens.—Reserved for separate note.

Annual Assembly of the Western Union Telegraph Company.—(Translation).

Poggendorff's Annalen der Physik und Chemie.

No. 10. 1873.

Determination of the Time of Oscillation of a Material Pendulum.—Dr. Bender.—The author's object was to devise a method which would obviate waste of time, and be free of that frequent source of error, the individuality of the observer. The apparatus is (briefly) made on the following principle:—If an electric current is sent through a Hipp chronoscope, the clockwork may be going, while the pointer remains stopped. But at the instant the current is interrupted, the pointer also moves. Such an interruption was effected through a second current, which was closed for an instant on the pendulum reaching its lowest position. This current also passes through a writer telegraph, recording the number of oscillations. Should the experiment be interrupted, a new stoppage of the chronoscope is necessary, and this was produced by means of a third, or *relay* current. The mode of action of these currents, as also of a fourth, the *pendulum* current, is fully described.

Remarkable Production of Light in Grinding of Hard Stones.—Dr. Nöggerath.—This note refers to a visit the author made to some agate works at Oberstein and Idar, in which various kinds of hard stone are pressed by the workmen (with their hands) against quickly-revolving grindstones. The transparent stones become pervaded throughout with a yellowish-red light, like that of red-hot iron. Opaque stones give a red light at the place of contact, with halo and sparks. Dr. Nöggerath thinks the phenomena worth studying by physicists, especially as regards development of heat and electricity.

On the Soldering of Platinised Glasses.—Dr. Röntgen.

Bulletino Telegrafico. October and November, 1873.

These two numbers are mainly devoted to the Government regulations in the matter of re-arrangement and amelioration of the telegraphic service in Italy.

Revista de Telegrafos. January 1, 1874.

This number contains no papers specially calling for notice.

January 15.

Spanish Telegraphy in the Year 1873. *Submarine Cables.*—There has been marked progress in telegraphy, notwithstanding the disturbed state of the country. The cable from Bilbao to Land's End was opened in January (1873). An interruption occurred in March fourteen miles from Bilbao, but the injury was repaired by the end of April. A worse interruption was caused by the blockade of Bilbao by the Carlists. Concession was given in the beginning of the year for a cable from Barcelona to Italy, in connection with the line from England to Bilbao; while a land line was to be made from Bilbao by Madrid to Barcelona for the cable despatches. But, owing to disturbances in the north, this scheme has been abandoned for a time; and M. Aparicio, to whom the concession for the Italian cable was transferred (from Mr. C. S. Stokes), is about to lay a cable from Barcelona to Marseilles. In June, a cable was completed (by the Telegraph Constrnction and Maintenance Company) from England to Vigo, and it was extended, in July, by another from Vigo to Lisbon. In January (1873), M. de Juan de Lasarte was authorised to lay a cable from the East coast of the Peninsula to Havannah, in

Cuba, passing through the Canaries. The concession has been transferred to M. Adolfo Clavé, and the plans, &c., have been submitted by Count de Brockman, an eminent engineer, but the civil war has prevented the necessary capital being supplied.

Telegraphy in the Philippines.—A letter from Lingayen gives a picture of the difficulties and privations encountered in the construction of lines in these islands.

City and Commercial Notes.

A PROSPECTUS has been issued of the Light Cable Telegraph Company (Limited), with a capital of £380,000, to lay a light line to America, *via* the Azores. The object of this Company is to promote cheap telegraphy by the use of light cables, by which ordinary messages can be transmitted at a uniform rate of one shilling for each word; and it is intended to open branch offices at Glasgow, Liverpool, and Manchester. A provisional arrangement has been made with the Submarine Telegraph Company for working the cable and conducting the business of this Company; and further, for the transmission by this Company's cable of all American messages received by the Submarine Company from the Continent, as well as all messages which this Company may receive from America for the Continent. On another page will be found reports of several eminent electricians on the practicability of the scheme. In a letter to *The Times* of the 13th inst., Mr. J. F. Corkran, the secretary of the new Company says:—"It has been stated in *The Times* that the possibility of the success of a light cable is disputed by the 'majority of persons experienced in ocean telegraphy;' but it would be difficult to prove the correctness of this assertion, as not only is the Board of the Light Cable Company composed of gentlemen of, at least, some experience in submarine telegraphy, but the feasibility of laying down and working light, deep sea cables has been determined by the authority of Sir Samuel Canning, Messrs. Varley, Sabine, Preece, France, and Bordeaux, all engineers and electricians of high reputation in their profession, and in the present controversy no single engineer or electrician has been found to deny the advantage of the 'light cable' scheme." On the 12th inst. the shares were quoted ½ to 1 prem.

The report of Hooper's Telegraph Works (Limited), to be presented on the 19th inst., shows an available total of £35,519, and recommends a dividend of £1 per share, making 17½ per cent for the year, and leaving £10,519 to be added to reserve, thus raised to £26,214. The Company are about to carry out a contract for a cable from the Cape *via* Natal and Mauritius to Aden. At the corresponding period of last year the dividend was 13s. 6d. per share.

The total traffic receipts of the Great Northern Telegraph Company have been, during January, 1874, 322,471 francs, and in corresponding period of 1873, 159,847 francs:—On the European lines—in 1874, 166,040 francs; in 1873, 121,377 francs. On the China and Japan lines—in 1874, 156,431 francs; in 1873, 38,470 francs.

The report of the Anglo-American Telegraph Company (Limited), presented on the 13th inst., states the receipts for the eight months since the amalgamation of the several lines to have been £547,906. An available total is now shown of £149,089, and a dividend of 2 per cent, making 6 per cent for the year, is recommended, leaving, after an appropriation of £40,000 for the new works and renewal fund (thus increased to £254,947), a balance of £9089 to be carried forward. In regard to insulation and working capacity, the directors state the new cable laid last year "has no equal in any part of the world." With regard to the 1865 cable, which was broken last year, the board have come to the decision that it will be inexpedient to renew the attempt to re-establish the line until next year, when they expect to be able to fit out an expedition comprising the most efficient staff and the ships best suited for the purpose, neither of which can be had this season. By the change of route of the 1873 cable, the Company became possessed of 900 miles of deep-sea cable, saved out of the length provided for the Porthcurno and Halifax line, the value of which may be estimated at £300,000. The Company have also some 126 miles of core in stock, capable of being made up in cable. The directors have determined to utilise this cable by laying a fifth line from Ireland to Newfoundland in the coming summer. The directors wish to provide beforehand for the further development of the constantly increasing traffic. A contract has been entered into with the Telegraph Construction and Maintenance Company, by which, for £475,000, they have undertaken to manufacture and lay 1100 miles of new cable, and to lay the cable already possessed by the Company between Valencia and Newfoundland, the *Great Eastern* being employed for the work. Of this sum, the greater portion will be furnished from the existing renewal fund and surplus profits of the present year, and the directors hope to be able to complete the payments without any permanent increase of the capital of the Company.

The Eastern Extension, &c., Telegraph Company's traffic receipts for the month of January amounted to £20,717 against £16,523 for the corresponding period of 1873, of the four separate lines, viz., the British-Indian Extension, China Submarine, British-Australian, and Tasmanian Submarine.

The Eastern Telegraph Company's traffic receipts for the month of January amounted to £37,037 against £33,287, in the corresponding period of 1873.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	Feb. 12.
Stock	Anglo-American (Limited)	100	78½—79
10	Brazilian Submarine..	9	3½—3 dis.
10	Cuba	All	7—7½
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	17	7½—6½ dis.
10	Eastern (Limited)	All	7¾—8
..	Do., New	..	102—103
10	Eastern Extn. Australia and China	All	7¾—8
10	Globe Telegraph and Trust	All	7⅝—7⅞
10	Do., 6 per cent Pref...	All	9⅝—9⅞
10	Great Northern	All	10—10½
25	Indo-European	All	15½—16½
10	Mediterranean Extension (Limited)	All	4—4½
10	Do., 8 per cent Pref...	All	11½—12½
10	Panama and South Pacific	2½	..—.. dis.
8	Reuter's..	All	11—11½
Stock	Submarine	100	235—245
1	Do., Scrip	All	2¼—2½
10	West India and Panama	All	5½—5¾
10	Do., 10 per cent Pref.	All	9¾—10
20	Western and Brazilian (Limited) ..	All	12½—13½
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	103—105
10	Hooper's Telegraph Works	All	13¼—13¾
50	India-Rubber and Gutta Percha ..	All	29—31
Cert.	Submarine Cables Trust	100	107—109
12	Telegraph Construction	All	32¼—32¾
100	Ditto Ditto 7 per cent Bonds	All	100—103

Patents.

1270. L. Weber, of Brussels. *Improvements in Galvanic Batteries.* Dated April 5, 1873.—The claims to this complete specification are:—First. The exclusive use and application of carburet of iron, of whatsoever denomination, quality, and production for generating electricity in galvanic cells and batteries generally. Second. The employment of a jar of particular shape, made of glass, of porcelain, or any other appropriate substance.

1395. R. Coddington, of Middlesex. *Improvements in Telegraphic Apparatus.* (A communication from Merritt Gally, U.S.A.) Dated April 17, 1873.—A revolving pendulum with motor, used as a unison device. Single keys representing a number of separate letters or characters. A conducting pile forming a repeating and adjustable circuit-closer. A pulsating device governing a number of transmitting or receiving instruments; the transmitting impulses of the transmitters occupying the intervals between the pulsations of the governor. More than two operating instruments in combination with a single telegraphic line, simultaneously employed and transmitting different messages in either or both directions, without conflict. A type-wheel with a reciprocating journal bearing. A paper-holding cylinder having its line of printing around its circumference, and a longitudinal movement for placing the position of the lines. The paper-holding cylinder containing the paper internally, to be supplied to the outside. A number of paper-holders coming one after another into position, so that the printing may be continued on one while the message is being removed from another. The type-wheels or gear of a number of instruments made to differ relatively in position, so that the printing impulses of one instrument will not cause the other to print, but that they may print severally by different successive impulses. A heading or form-wheel in connection with a telegraphic instrument or type-writer; also a paper-creaser or marker. A sounding device in combination with a printing telegraph, so that the instrument may print and sound simultaneously. A number of cyphers upon a type-wheel, which may be used singly or in numbers, during a single revolution of the type-wheel. An improved magnet giving an increased number of magnetic impulses. An improved method and means for automatic operation.

1554. W. R. Lake, of London. *Improvements in Printing Telegraph Apparatus.* (A communication from W. F. Coffee, of New York. Dated April 29, 1873.—These consist, first, in the application of an electro-magnetic shunt, and its connections for causing the printing to be done by the main current. Secondly, in a unison mechanism whereby each station is made to bring the type-wheels in the same circuit into harmony with its transmitting apparatus. Thirdly, in a peculiar arrangement for stock exchange quotations, of the characters on the type-wheel. Fourthly, in a combination of the shunt, the unison mechanism, the type wheel, the escapement, the clockwork, the printing magnet, and a lever and roller.

1558. J. T. Sprague, of Birmingham. *Improvements in Instruments for Measuring Electric Currents, Resistances, and Forces.* Dated April 29, 1873.—Galvanometers are constructed with several circuits having deflective powers increasing in definite ratios as 1, 10, 100, so that the one graduation serves to measure currents passing through them. The dials are graduated to indicate currents in definite units, such as vebers, or to measure for practical purposes, such as the weight of metal deposited per hour. The dials are also graduated to indicate directly the resistance of the circuit in ohms or other units without requiring a resistance instrument by using a standard battery; and to indicate the electromotive force of a cell or battery in bolts by making the resistance one or more ohms as required.

1584. F. Fisk, of Middlesex. *Improvements in Electric Printing Telegraphs.* (A communication from A. Bauer and F. Kreb, both of Vienna, Austria.) Dated May 2, 1873.—This invention consists in methods (1), of working the instruments for the purpose of moving the type-wheels and printing the types so that any number of receiving instruments may be placed in the circuit; (2), of inserting the instruments in the circuit; (3), of controlling the working of the printing-wheels; (4), of giving from the transmitting station to any instrument in the circuit, not having its type-wheel correctly set, a position corresponding with that of the other instruments; (5), of transmitting the currents by means of the keys.

1585. G. T. Bousfield, of Sutton, Surrey. *Improvements in Torpedoes.* (A communication from Colonel Von Scheliha, of St. Petersburg, Russia). Dated May 2, 1873.—This Provisional Specification describes a locomotive torpedo driven by a compressed air-engine which is steered from shore by means of an electric cable which is paid out by the torpedo. Means of keeping the torpedo at a constant depth under water and of starting and stopping it are described. The torpedo carries on its back a number of charges each in a separate case, and these can be detached and exploded at the will of the operator.

1586. C. A. McEvoy, of the London Ordnance Works, Southwark, Surrey. *Improvements in Apparatus to be used when Firing Fuses by Electricity.* Dated May 2, 1873.—This Specification describes apparatus for indicating when an electric fuse has been fired, and for cutting off at the same time from the battery the wire which previously led to such fuse; also a contact maker to be used for coupling up a battery to a wire leading to an electric fuse for the purpose of firing it.

Meteorological Society.—At the annual meeting of this Society, held on the 21st ult., the following gentlemen were elected Officers and Council for the ensuing year:—President.—Robert James Mann, M.D., F.R.A.S. Vice-Presidents.—Charles Brooke, M.A., F.R.S., F.R.C.S.; George Dines; Henry Storkes Eaton, M.A.; Lieutenant-Colonel Alexander Strange, F.R.S. Treasurer.—Henry Perigal, F.R.A.S. Trustees.—Sir Antonio Brady, F.G.S.; Stephen William Silver, F.R.G.S. Secretaries.—George James Symons and John W. Tripe, M.D. Foreign Secretary.—Robert H. Scott, M.A., F.R.S., F.G.S. Council.—Percy Bicknell, Arthur Brewin, F.R.A.S.; Charles O. F. Cator, M.A.; Rogers Field, B.A., Assoc. Inst. C.E.; Frederic Gaster; John Knox Laughton, M.A., F.R.A.S.; Robert J. Lecky, F.R.A.S.; William Carpenter Nash; Rev. Stephen J. Perry, M.A., F.R.A.S.; Captain Henry Toynbee, F.R.A.S.; Charles Vincent Walker, F.R.S.; E. O. Wildman Whitehouse, Assoc. Inst. C.E.

To Correspondents.

⁂ Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publisher.

Mathematician.—Thanks for your analysis of our title, "Mathematics for Non-Mathematicians." The present papers certainly do not admit of such a rendering. We gladly accept your suggestion.

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